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EVALUATING THE NEED FOR FOLIAR N BASED ON FIELD TESTING, SOIL N RATES, AND FOLIAR N SOURCES

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Justification

Nitrogen (N) fertilization of cotton (*Gossypium hirsutum* L.) affects yield, maturity, and lint quality. Cotton's response to N fertilization varies with climate, soil, topography, cultivar and management of the producer. Optimum N is essential to maximize yield and improve fiber quality, while excessive or deficient N applications may reduce lint yields (Maples and Keogh, 1971). A high N application rate may produce excessive vegetation, delay maturity and harvest, and may reduce yields and affect lint quality due to early frost or prolonged fall rain (Hutchinson et al., 1995; McConnell et al., 1995). On the other hand, applying a low N rate causes premature leaf senescence and reduced yields (McConnell et al., 1995). The optimum N rate for production on a field may differ from the recommended rate due to differences in soil and producer management skills. Traditionally, producers tend to apply a higher N rate than is recommended to compensate for possible N losses, poor fertilizer distribution, etc.

Plant nutrient monitoring programs are available in certain states allowing producers to evaluate the adequacy of their fertilization program. However, these programs are not available to all producers. A potential problem associated with the petiole analyses program is the time differential between sampling and data reception by the producer. In some instances this time differential may delay N applications and reduce yields. Field analyses that would provide nutrient sufficiency or deficiency would eliminate any time differential. Also, the methodology would be available to producers throughout the cotton producing states

Correlating petiole N levels to predict nutrient sufficiency or deficiency is primary to any methodology. Plant N concentrations are constantly changing throughout the growing season and begin to decrease at pinhead square making the correlation more critical. Research conducted in 2001 (Kenty, et al., 2002a), provided the initial correlation for cotton petiole N and K levels and Cardy meter readings. These critical Cardy meter levels were calculated based on the Arkansas critical levels.

Time of N deficiency determinations affects application method. Early determination, at or before pinhead square, allows N to be soil applied. However, determinations after flowering general indicate the need for foliar applications because of the time interval needed between soil application and plant uptake. At this growth stage, soils are generally dryer restricting both soil nutrient movement and root growth. Also, the fast-fruiting, high-yielding cultivars fill bolls over a shorter time compared with older cultivars making timely N applications more critical. Nutrient absorption is quicker from foliar applications than soil applications.

Both producers and researchers have questioned increased yields from foliar fertilization. This skepticism is justified since yield responses in certain areas have been either non-existent or very small. Several factors may be listed that may restrict yields from foliar applications. These factors include, poor growth conditions following application, late application timing, plant N was not determined and was not deficient, and deficiency of other nutrients may have been the yield-limiting factor. Howard et al. (1998) showed a yield response to foliar applying K to no-till cotton for with no response to foliar N on a low extractable K soil. In other research, Howard et al. (1997) reported a yield increase to foliar N when K was not a yield-limiting factor. Kenty et al. (2002b) showed higher lint yields from foliar applying N and K on certain locations relative to only foliar N.

Nitrogen sources, KNO_3, $Ca(NO_3)_2$, and feed grade urea, traditionally used for foliar applications are subject to removal from the leaf by irrigation or rainfall. CoRoN®[1], a foliar N source have some advantages producers may need to consider. CoRoN is a controlled release N source and adheres to the leaf better than the other sources. These two traits may allow CoRoN to be more efficient and effective over a longer time period than other foliar N sources.

Objectives

To customize N fertilization of cotton for individual production fields by evaluating:

- the effect of applying two N rates.
- petiole Cardy meter N and K levels each week following pinhead square.
- two foliar N sources.
- these effects on cotton production at selected areas based either on climate or soil differences.

Procedures

Field investigations were conducted at selected locations through the cotton belt states in 2001 and 2002, with more than one location in certain states. States, and site number (number in parenthesis) were North Carolina, South Carolina, Georgia, Alabama, Mississippi (2), Louisiana (2), Tennessee, Arkansas (2), Missouri, Texas (2), Oklahoma, New Mexico, and Arizona. Research was conducted two years at each site except for three locations, Texas Tech in 2002, Alabama and New Mexico in 2001. The research was conducted in cooperation with University personal and private consultants.

The experimental design was a randomized complete block with treatments replicated four to six times. Row lengths ranged from 30 feet (small plots) to 300 feet (producer fields) with a minimum width of four rows. Treatments included two N rates; the recommended rate for the area and 2/3 the recommended rate. Individual treatments included; 1.) the recommended N rate with no foliar N or K, 2.) The 2/3 N rate with foliar urea, 3). the 2/3 N rate with foliar CoRoN, and, 4). the 2/3 N rate with no foliar N or K applications. Feed grade urea was applied at 8 to 10 lb N/acre and if K was deficient, any of several foliar K materials could be applied in 2001. In 2002, the foliar K source was 2-0-25 applied at one gal/acre. Foliar boron (B) was applied at pin-head square at 0.2 lb B/acre to three treatments, foliar urea, high, and low N (non-foliar) treatments. Foliar B was applied at pinhead to the CoRoN treatment using a 12-0-0-0.5 (HM9826-A) @ 1qt/acre. Foliar phosphorus (HM9870) was applied at mid-bloom at 2 qt/acre. Foliar N was applied either as a 25-0-0-.5 (HM 9309) at one gal/acre when ambient temperatures were below 100°F or as 28-0-0 (HM 9716) at 3 qts/acre when temperatures were above 100° F. If both N and K were to be foliar applied, 10-0-10-.5 (HM9827) was applied at 2.5 gal/acre (2.25 to 2.5 lb N and K_2O/acre).

Foliar treatments were to be applied in 10 gal/acre water providing adequate coverage with the material remaining on the plant. Nozzles were oriented over the row and foliar materials applied at a pressure of 20 to 40 psi.

[1] CoRoN® is a registered trademark of Helena Chemical Company.

Soil P and K applications were determined by soil test. These nutrients were applied prior to or at planting. The N treatment was applied at planting or as a side-dress. Recommended fungicides and insecticides for cotton production applied when needed.

The Cardy nutrient meter was used to evaluate petiole N and K levels. Analysis was initiated at bloom and continued on a seven day interval until plant cutout. Approximately 30 petioles were collected from the top-most mature leaf, generally the third or forth leaf from the top. Leaves were detached and the petioles cut into ¼ to ½ inch lengths placed in a garlic press with the sap either squeezed into a beaker or onto the N and K Cardy Meters. The recorded values were an average of several readings. Foliar N and K were applied when the meter readings were lower than the critical level, which was based on growth stage. The 2001 critical N and K levels were used in previous research (Kenty et al., 2002b). The 2002 critical N and K levels were established from correlations conducted in 2001 by Kenty et al. (2002a). Cardy meter N and K readings were correlated with petiole N and K concentrations determined by the University of Arkansas. The 2002 critical Cardy meter N readings were 1370 through the second week of flowering and 1240 third week of flowering and decreased with each successive week. The initial critical Cardy meter K reading was 3520 decreasing to 3260 the second week and continued to decrease with each successive week after flowering.

Statistical analyses of treatment effect on yields was conducted utilizing SAS Mixed Model procedure (SAS Ins., 1997). The Mixed Model procedure provides Type III F values but does not provide mean square values for each element within the analysis or the error terms. Mean separation was accomplished through a series of protected pair-wise contrasts among all treatments (Saxton, 1998). Regression analyses of the Cardy meter N analysis as a function of days after emergence (DAE) were evaluated using SAS.

Treatment yields and petiole N concentrations were averaged for each location and treated as a replication for the statistical analyses. Two yield analyses was conducted, the first to evaluate lint yields from each location and the second to evaluated relative yields to normalize data due to weather, soil, or cultivar variations. Relative yields were calculated as a percent based on the highest treatment mean for each location and year.

Results and Discussion

Yields

The ANOVA shows two-year lint yields from the selected locations were affected (P = 0.006) by the treatments (Table 1). Relative yield evaluations (used to normalize data variation) were significant at P = 0.001. This difference in probability levels provides some insight into the amount of variation due to year, weather, soils, cultivar etc. There was no significant difference in yields for the two years (Table 2). Also, the treatment effect on yields was consistent over the two years since the year-by-treatment interaction was not significant.

Yields were increased 36 lb/acre by increasing the soil applied N rate from 2/3 N rate to the full N rate (1008 lb vs. 1044 lb., Table 3). Foliar applying CoRoN resulted in comparable yield increase (34 lbs) relative to foliar applying urea (1067 lb vs. 1033 lb). In general, urea has been an accepted foliar N source for cotton production. However, foliar urea did not increase yields when compared with the 2/3 recommend soil applied N rate. The lack of yield response may be responsible for some of the skepticism producers and researchers have toward foliar fertilization. The realization that potential N deficiencies can be corrected from foliar applications of CoRoN allows both the producer and consultant to begin customizing N fertilization of producers' fields. Soil applied N rates can be reduced to promote more efficient production and if weather conditions dictate the need for additional N, as determined by petiole analyses, a foliar application of CoRoN can provide the N allowing for higher yields.

The foliar CoRoN applied at the 2/3 N rate resulted in yields comparable to the high N rate providing some indication that foliar N applied after bloom was needed for optimum yields even though soil applied N appeared to be adequate.

Petiole N Concentrations

The reduction in petiole N concentration, average of the four treatments, between flowering and cutout for the four treatments are presented in Figure 1. The rate of decrease, slope of the equation curve, was greater for the 2/3 N rate followed by the CoRoN, urea, and high N treatments. The fit of the regressed equation with the N concentrations for the locations varied considerably as indicated by the low R^2 values ranging from 0.15 to 0.21. This suggests that several of these locations may need to be considered independently of the others.

The regressed equations predicting petiole N levels, as determined by the Cardy meter, as a function of time, days after emergence (DAE), varied for the various locations indicating the need to group the locations by equation type (data not presented). It is interesting that the equations varied from a cubic to a linear. These regression equations include the 2001 and 2002 data. In 2001, the equations expressing the N levels were cubic and quadratic (Thomas et al., 2002). In 2001, the equation R^2 values were above 0.50, which in itself indicates a considerable amount of variation for each site. This variation was primarily attributed to weather variations during the growing season. The two-year R^2 values, of this study, are lower relative to those for 2001, which would include two years of weather variations on petiole N levels.

Conclusions

1. Replicated field tests conducted over a two-year period at selected locations throughout the cotton producing states showed yields to be reduced by applying 2/3 the recommended N rate relative to the recommended N rate.

2. Foliar applying CoRoN significantly increased lint yields relative to foliar applying urea when the soil N rate was 2/3 the recommended N rate.

3. Soil applying 2/3 the recommended N rate plus foliar applying CoRoN resulted in yields comparable to applying the recommended N rate.

4. Yield increases from foliar applying CoRoN allows the producer to reduce the soil applied N rates, monitor plant N status throughout the growing season and N can be corrected if deficiencies are encountered.

5. Determining the petiole N concentrations with a Cardy meter appears to have a functional use throughout the cotton belt. However, determinations will vary with year and location.

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Table 1. Mixed model 'F' statistical values for lint yields and relative lint yields of cotton produced at 16 locations throughout the cotton belt.

		16 locations			
		Lint yields		Relative Yields	
Source	**df**	**"F"**	**P>F**	**"F"**	**P>F**
Year (Y)	1	0.27	0.618	0.90	0.344
Error a	3				
Nitrogen (N)	3	4.59	0.006	6.20	0.001
Y * N	3	0.86	0.464	0.62	0.607
Error a	81				

Table 2. Cotton lint yields and relative yields for cotton produced over the two years.

	Two year data	
Year	**Lint yields**	**Relative Yields**
2001	1083 a	942 a
2002	995 a	951 a

Table 3. Effect of N treatments (soil and foliar applied) on lint and relative yield of cotton produced on 16 locations.

Treatments	**Yield lb/acre**	**Relative Yield**
Recommended N rate	1044 ab[†]	0.951 ab
2/3 N rate + urea	1033 bc	0.941 bc
2/3 N rate + CoRoN	1067 a	0.976 a
2/3 N rate	1008 c	0.919 c

[†] Yield means within a year column by soil, followed by the same letter, are not significantly different at • = 0.05

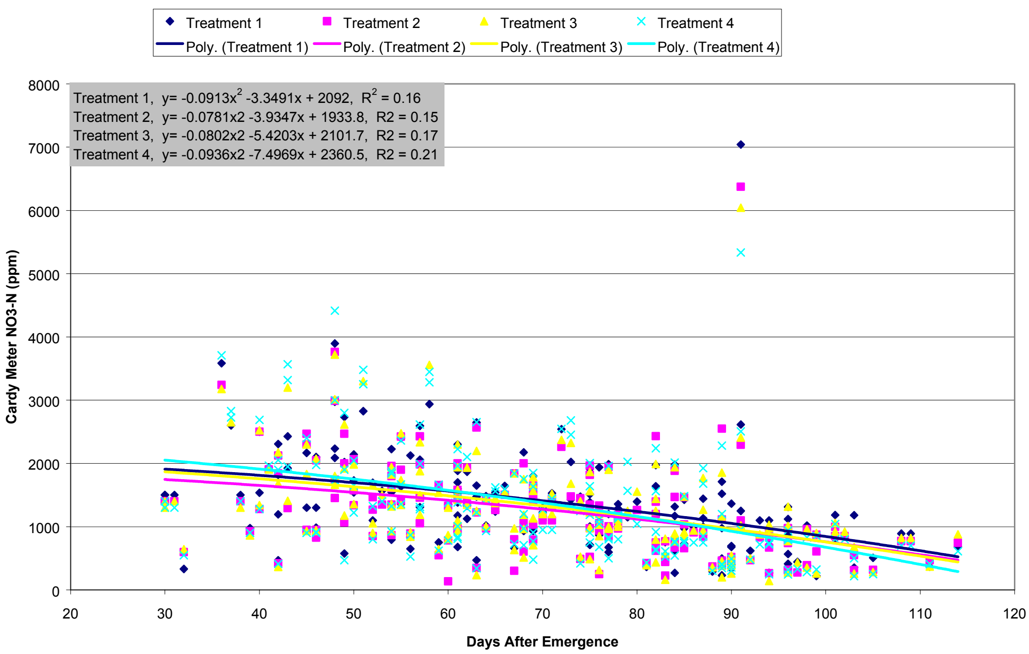

Figure 1. Petiole N concentrations for the four treatments thru the growing season.